A PROPOSAL FOR ESTABLISHING

THE PHOENIX MEMORIAL ENERGY INSTITUTE

OF THE UNIVERSITY OF MICHIGAN

MICHIGAN ENERGY RESEARCH COUNCIL

JUNE 1, 2006

EXECUTIVE SUMMARY

There are few contemporary challenges facing our state, the nation, and the world more threatening than the unsustainable nature of our current energy infrastructure. Every aspect of contemporary society is dependent upon the availability of clean, affordable, flexible, and sustainable energy resources. Yet our current energy infrastructure, heavily dependent upon fossil fuels, is unsustainable. Global oil production is expected to peak within the next several decades, with natural gas production peaking soon afterwards. While there are substantial reserves of coal and tar sands, the mining, processing, and burning of these fossil fuels poses increasingly unacceptable risk to both humankind and the environment, particularly within the context of global climate change. Furthermore, the security of our nation is threatened by our reliance on foreign energy imports from unstable regions of the world, particularly in the Middle East.

The likely collapse of our fossil fuel energy economy poses a particular challenge for the state of Michigan, still heavily dependent upon the automobile industry. Ground transportation utilizes 50% of the petroleum consumed in the United States. Furthermore, the Great Lakes states are both the largest producer and consumer of electrical power, primarily dependent upon coal-fired plants. Hence the implications of the unsustainable nature of fossil fuels are very serious for the future of our state.

Given this urgency, we believe the University of Michigan has both the obligation and opportunity to build a world-class capability in energy research, with a particular focus on advanced energy sources, more efficient energy utilization, energy policy, and global sustainability. Furthermore, such an endeavor would align well with numerous evolving research and funding opportunities aimed at clean and renewable energy generation and efficient utilization in both government and industry. It would also hold the potential of both sustaining many of Michigan's existing industries while stimulating new regional economic activity in energy technologies. It would also assist the State of Michigan in charting its course for job growth and economic stability relevant to our future energy needs.

Thus, the University of Michigan must build its strength in three important areas. First, we must continue *to attract and develop our expertise in emerging areas of energy research*. Second, we *must develop institutional structures to coordinate and advocate energy research* both within and outside the university. Third, we must *provide flexible resources* that can be dedicated to developing and sustaining a broad array of research in energy science, technology, and policy.

The Michigan Energy Research Council (see Appendix C for list of MERC members) endorses the initiative proposed by the Vice President for Research to build focused strength in key areas of energy research that will complement existing strengths. The Office of the Vice President for Research will work with the Schools and Colleges to bring to Michigan leading researchers who can help grow world-class research programs in emerging areas of energy research.

Broad based support for the energy sciences, technology, and policy at the University of Michigan will be provided with the formation of a new research institute- the *Phoenix Memorial Energy Institute*. Positioning Michigan as a leader in energy research requires a structure capable of supporting and expanding multidisciplinary research. To accomplish this, the proposed Institute will be *enabling* rather than an operational or managing organization. It will be a focusing mechanism for the broad spectrum of University energy expertise and programs. Its functions would be to *coordinate* (research projects, partners, or clients), to serve as a *clearinghouse* linking expertise both on and off campus, to assist in identifying and *developing* research opportunities (perhaps enabled with seed funding), to *market* the University's capabilities in energy research (to government, industry, and the public), to stimulate the development of *educational* programs, and to manage those *facilities* designed to support University-wide, multidisciplinary research activities.

The Phoenix Memorial Energy Institute will build on the legacy of the Michigan Memorial Phoenix Project, founded at the end of World War II, which was devoted to the peaceful use of nuclear energy. This opportunity was provided in a Regental action in 2004 that broadened the charter of the Phoenix Project, Michigan's World War II Memorial, beyond atomic energy to encompass "research on the development of energy policies that will promote world peace, the responsible use of the environment, and economic prosperity." The new charter furthermore stresses interdisciplinary research and education that encompasses "perspectives from the natural and social sciences, engineering, medicine, and the arts and humanities." To this end, the Phoenix Memorial Laboratory is already being renovated with State of Michigan and University funding to become a multipurpose energy research laboratory.

Rededication of the Phoenix Institute would be accompanied by a campaign to re-establish a significant endowment that would be used to underwrite the activities of the institute and support energy research across the campus. Our goal would be to endow the institute with at least $70 million, which is the value of the original endowment in today's dollars. Revenue generated by this endowment would be used to

support the activities of the institute and provide a pool of flexible resources that will be deployed to develop and sustain a broad range of energy research.

THE CONTEXT

The Importance of Energy Research

Michigan's current economy–indeed, the United States economy and security–is based upon the availability of cheap energy. Yet, there are few contemporary challenges facing our nation more threatening than the unsustainable nature of our current energy infrastructure. Every aspect of contemporary society is dependent upon the availability of clean, affordable, flexible, and sustainable energy resources. More specifically, our current transportation industry is heavily dependent on the availability of petroleum, over 60% of which is imported, predominantly from unstable regions such as the Middle East. Despite the increasing uncertainty of foreign markets, there has been relatively little effort in the United States to reduce dependence on foreign oil.

Recent analyses of world petroleum production and known reserves suggest that global oil production could peak as early as the next decade (with gas production peaking roughly a decade later). The consequence of passing over the global production peak is not the disappearance of oil; roughly half of the reserves would remain. Rather it would be a permanent imbalance between supply and demand that would drive oil prices dramatically higher than today's levels–$100/bbl, $200/bbl, and beyond–with corresponding increases at the pump. The rapidly increasing oil and gas demands from developing economies such as China, India, and Latin America make this imbalance even more serious, particularly when it is noted that the United States currently consumes 25% of world production.

To this should be added the increasing consensus that utilization of fossil fuels in energy production is already causing significant global climate change. Evidence of global warming is now incontrovertible–increasing global surface and air temperatures, receding glaciers and polar ice caps, rising sea levels, and increasingly powerful weather disruptions, all confirm that unless the utilization of fossil fuels is sharply curtailed, humankind could be seriously threatened. Although there continues to be disagreement over particular strategies to slow global climate change–whether through regulation that restricts the use of fossil fuels or through market pressures (e.g., "cap and trade" strategies)–there is little doubt that energy utilization simply must shift away from fossil fuels toward non-hydrocarbon energy sources.

A recent assessment by the U. S. Department of Energy in the spring of 2005 warned, "The world has never faced a problem like this. Without massive mitigation more than a decade before the fact, the problem will be pervasive and will not be

temporary. Previous energy transitions (wood to coal and coal to oil) were gradual and evolutionary; oil peaking will be abrupt and revolutionary." (Hirsch, 2005)

The implications for our state are particularly serious. The unsustainable nature of current energy technologies (fossil fuels) puts at great risk Michigan's existing industry and future economic prosperity. Over 500,000 Michigan jobs, directly or as a multiplier, are dependent upon energy and related industries (e.g., transportation and electrical power generation). Spiking of gasoline prices to Asian and European levels (currently $6 per gallon and above) would likely obliterate what remains of the American automobile industry, since it is unlikely that domestic companies would be able to shift rapidly enough to the small, fuel-efficient cars produced by Asian manufacturers or adept enough to exploit hybrid, electric, or hydrogen fuel technologies. Furthermore, manufacturing industries of the Great Lakes currently utilize 38% of the nation's electricity, produced primarily from coal-fired plants. Should electrical power generation from fossil fuels be sharply curtailed or should prices skyrocket through regulatory requirements for carbon sequestration, there is little likelihood that our remaining industrial capacity would remain competitive in the global economy.

Alternative energy technologies such as electric- or hybrid cars, hydrogen fuels, nuclear power, and renewable sources such as solar, wind, or biofuels still require considerable research and development before they evolve to the point of massive utilization. Yet over the past two decades, energy research has been sharply curtailed by the federal government (75% decrease), the electrical utility industry (50% decrease), and the domestic automobile industry (50% decrease). It has become increasingly clear that the bulk of the scientific research necessary to support the development of new energy technologies in the United States must be conducted by our nation's research universities and national laboratories. It is imperative that the University of Michigan, long ranked as one of the nation's leading research universities with strength in the scientific and policy disciplines critical to alternative energy technologies, play a key role in developing world-class energy research and education programs.

Existing Energy Research Activities at the University of Michigan

The University of Michigan has a reputation as one of the world's leading research universities. Its faculty members have critical relationships with key organizations that are participating in vital energy research issues, both for the nation and for Michigan. The U.S. Department of Energy (DOE), U.S. Department of Defense

(DOD), National Automotive Center (NAC), NextEnergy (NE), General Motors Corporation (GE), Ford Motor Company (Ford), and DaimlerChrysler Corporation (DCX) are among the many important entities that sponsor research projects at the UM in the energy field. Most of the University's energy research portfolio (currently in excess of $35 million) consists of individual and small groups of faculty in areas such as:

- Compact gasoline fuel processors for hydrogen production for PEM fuel cells
- Fuel processors for logistics fuel (JP-8) for solid-oxide fuel cell auxiliary power units
- Advanced catalysts and processes for hydrogen generation from fossil fuels
- Hydrogen production from nuclear energy
- Sulfur removal from hydrocarbon fuels
- Synthetic fuel production
- Modular hydrogen production systems based on numbering-up of digital microreactors
- Biomass conversion
- Hydrogen storage
- Portable micro-fuel cells
- Advanced anode and cathode catalysts for fuel cells
- Control of fuel cell power systems
- Advanced battery concepts
- Internal combustion engine/battery hybrid propulsion technologies
- Hydrogen burning combustion engines
- Clean diesel engine technology
- Sustainable energy and life cycle analysis
- Energy policy, infrastructure, and entrepreneurial studies
- Industrial energy conservation

In recent years, University faculty have established several large research centers that address energy issues or, closely related to energy, environmental sustainability. These include:

- Automotive Research Center (Assanis)
- Center for Sustainable Systems (Keoleian, Bulkley)
- Engineering Research Center for Reconfigurable Manufacturing (Koren)

- Engineering Research Center for Wireless Integrated Microsystems (Wise)
- ERB Institute for Sustainable Global Enterprise (Hoffman, Gladwin, Lyon)
- Graham Environmental Sustainability Institute (Kohrs, Semrau)
- Hydrogen Energy Technology Laboratory (Thompson)
- Transportation Energy Center (Schwank)

These center activities are complemented by projects in specific UM academic units focusing on energy. This includes work in the School of Natural Resources and Environment, Ross School of Business, Literature, Science and Arts, the College of Engineering, and the UM Transportation Research Institute.

The University of Michigan has several significant strengths that make it an ideal location to be a premier institution leading international efforts in energy research. Below are listed only a few reasons why UM is the natural locale to initiate this effort:

1. The expanded hydrogen initiative under Prof. Levi Thompson
2. The Nuclear Engineering program is top rated among US universities
3. UM's profile in automotive engineering, including its relationship to energy efficient transportation, is also top rated in the US, and possibly internationally.
4. The Nanoscience Initiative has provided important baseline technologies and efforts that are directly related to energy generation and utilization. The new CoE/LSA joint faculty hiring initiative is currently being directed, if possible, toward identifying a leading faculty member who has related interests in nanoscience and energy.
5. Considerable high-visibility efforts in micro-fabrication and solid state device approaches to energy generation and efficient utilization are underway at UM anchored by the investments in the Solid State Electronics Laboratory.
6. UM's Schools of Natural Resources and the Environment, LS&A, the College of Engineering and others all have achieved significant attention through efforts in energy-related research. Overall, by some counts there is $35 million in energy related research currently pursued at UM.
7. The upper Midwest region, and the US in general, are in need for an economic transformation that is offered by innovations in energy generation and its efficient use. UM is the largest, broadest and deepest educational institution in the region with the resources and vision to effect this transformation.

8. There are roughly 20 companies in SE Michigan alone that have significant efforts in energy commercialization. The State of Michigan has made energy research and the accompanying economic development a major focus of its 21st Century Jobs Fund competition, and through recent announcements by government leaders, strengthened the state profile in this area.
9. While science and technology ultimately guide approaches to the practical solution to impending shortages in energy availability, there are numerous areas that influence the decisions and policy on how to mitigate the effects of this problem. The social impact of lack of energy, the vulnerability of societies beholden to sole-source suppliers, climate change, and clean up are only a few of the many issues that are vital to developing a coherent societal response to our increasing energy usage and the deficits that are engendered. Only a handful of institutions worldwide are prepared to take on energy issues in the broadest possible sense. UM is one of them.
10. The deans of the major science-based schools (e.g. SNRE, CoE, LSA) have engaged OVPR in discussing means by which they can make significant contributions to the success of university-wide initiatives in this area. Again, this emphasizes the ground-up nature of this field of research.

The President's recent State of the Union Address highlighted the need for energy independence, with the Department of Energy leading the effort to develop sustainable energy technologies that would reach the level of "the next Manhattan Project". Already there are strong signs indicating a rapid increase in federal funding of energy R&D, providing an exceptional opportunity to approach state, federal, and industrial sponsors for the support of a University-wide energy center.

Up to now, the many UM energy activities have been carried out in a scattered and uncoordinated fashion, with the University at a competitive disadvantage. Other universities are moving ahead rapidly to create coordinated energy research activities, recruit top faculty, and secure the necessary funding from the public and private sector. Stanford has created the Global Climate and Energy Project funded by an industry consortium. Texas A&M has established a Center for Electrochemical Systems and Hydrogen Research. Georgia Tech has set up a Center for Innovative Fuel Cell and Battery Technologies and in fact recruited away one of our leading energy experts. Case Western Reserve University has launched CAPI, the Case Advanced Power Institute, with multi-million dollar funding from the State of Ohio. Lastly, M.I.T. has recently formed the Laboratory for Energy and the Environment.

There is a window of opportunity to seize leadership in this critical area, provided the University acts quickly and decisively.

Early Planning for a Major Energy Research Initiative

For the past two years there have been ongoing discussions about launching a major research effort in energy research at the University of Michigan. This began in 2004 with a small group of faculty and friends of the University exploring the possibility of a major federally funded initiative in hydrogen-based energy sources. Vice President Ulaby appointed an ad hoc committee, the "Hydrogen Initiatives Committee" to explore these possibilities. After a few meetings, it became clear that while hydrogen would be an important area of investigation, the impact of the University could be over a much broader spectrum of energy research, albeit with much of it focused on the future of the transportation industry. Our efforts to inventory UM's current research activities in this area came up with over $35 million of ongoing sponsored projects. Hence, part of the challenge was to create a more visible whole from the fragmented existing parts.

Several other events reinforced the wisdom of aggressively exploring a major University-wide effort in energy research. First, the repurposing of the Michigan Memorial Phoenix Project into broader energy research (beyond its original mandate for peaceful applications of atomic energy) and the commitment to renovate the Phoenix Memorial Laboratory for broader energy research activities provided an important resource. Here, it is important to stress that the Phoenix Project was, in fact, the University's memorial to the 579 members of the University community who gave their lives in World War II. (A more detailed history is provided in Appendix A.) Although it is primarily an experimental facility, the Ford Nuclear Reactor, is in the process of being decommissioned., It is extremely important that the historical significance of the Phoenix Memorial be preserved . When it was launched in 1948 to conduct research on peaceful uses of atomic energy, President Ruthven called the Phoenix Project "the most important undertaking in the University's history." During the next half-century, the Phoenix Project had a remarkable impact both through its research on nuclear science and technology and its educational programs. It pioneered the sciences of neutron inelastic scattering and radiography, developed new radiopharmaceuticals, and developed the technology to shift research reactors around the world to low-enrichment (non weapons-grade) uranium, thereby making major contributions to nuclear nonproliferation efforts. It attracted world-renowned scholars such as Robert

Oppenheimer and Hans Bethe as visitors to Michigan. And it supported the activities of thousands of students and faculty in nuclear research and education.

As we begin a new century, the challenges facing our world have changed significantly. Today it seems altogether appropriate that the Phoenix Project be rededicated to a new purpose, befitting its war memorial status and sustaining its impact. The new mission approved in 2004 by the Regents, *to conduct research on the development of energy sources and energy policies that will promote world peace, the responsible use of the environment, and economic prosperity*, seems appropriate within this historical context. So too does the proposed role of the Phoenix Project in *coordinating the research activities from a variety of disciplines that are presently dispersed among multiple schools and colleges, including research on energy generation from sources such as nuclear, hydrogen, solar, wind, and geothermal, as well as energy storage, energy management, and energy policy*. The interdisciplinary nature of the Phoenix Project is intended to encompass *perspectives from the natural and social sciences, engineering, medicine, and the arts and humanities*. (The full text of the Regental Communication is provided in Appendix B.)

To explore such options and opportunities, the Hydrogen Initiatives Committee was merged with the Executive Committee of the Michigan Memorial Phoenix Project and expanded to include broader representation throughout the University. This new body, the University of *Michigan Energy Research Council* (MERC) was charged with the task of developing a plan and recommendations for a major energy research effort at the University of Michigan.

Since its formation in spring of 2005, the Michigan Energy Research Council has been meeting monthly to develop a plan for a University-wide energy research institute based on a repurposing of the Michigan Memorial Phoenix Project. This has involved a series of strategic exercises, such as a Strength-Weakness–Opportunity-Threat (SWOT) analysis of current University capability in energy research, an assessment of the potential for support from federal agencies (particularly DOE, DOD, and NSF), state government, industry, and private donors. Members of the Council have also consulted with the leaders of Michigan industry as well as the state and federal governments.

The Michigan Energy Research Council is now prepared to submit its plan for the establishment of *the Phoenix Memorial Energy Institute*. Such action is particularly timely with the arrival of a new University Vice President for Research, Dr. Steven Forrest, who has both a strong interest and an international reputation as an investigator in energy sciences. Vice President Forrest, as one of his highest priorities, has moved rapidly to identify University leadership in energy research. The Vice President has recently submitted to the University a plan to build faculty strength in key areas

addressing energy sciences. The Council is strongly supportive of this initiative and views it as an important first step in forming the Phoenix Memorial Energy Institute.

THE PLAN FOR DEVELOPING THE PHOENIX MEMORIAL ENERGY INSTITUTE

Role

To position the University of Michigan as a leader in energy sciences, technology, and policy, the Phoenix Memorial Energy Institute (PMEI) would carry out the following primary functions:

1. Facilitate and support multidisciplinary research in the field of energy by leveraging existing programs and nurturing new ones. Address fundamental science and technology energy issues, as well as business and policy, as these relate to energy issues;

2. Be a catalyst for enhancing University infrastructure and faculty expertise in energy-related research and education;

3. Build and sustain strong linkages between basic and applied energy research and educational activities on campus and other closely University programs, including the Graham Institute Environmental Sustainability Institute; the Erb Institute for Global Sustainable Enterprise; and the Science, Technology, and Public Policy Program;

4. Position the University to respond effectively to new initiatives such as the American Competitiveness Initiative, the National Academies "Rising Above the Gathering Storm" agenda, and the National Innovation Initiative of the Council on Competitiveness;

5. Develop strategic opportunities for partnering with government, industry, and foundations;

6. Provide leadership in energy technology and policy research to assist the State of Michigan and the federal government in tackling energy issues;

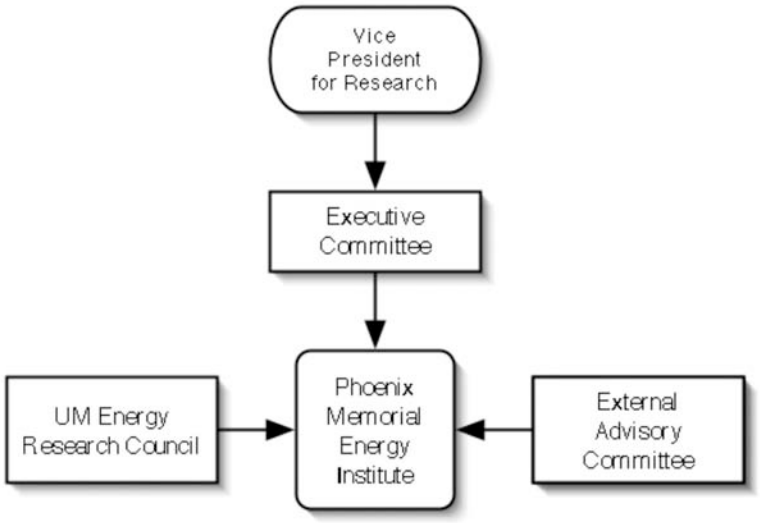
7. Facilitate the University's technology transfer efforts in energy technologies by assisting in the development and commercialization of intellectual property, with particular attention given to technology-based economic development in the State of Michigan.

The Michigan Energy Research Council views the Phoenix Institute as an *enabling* rather than an operational or managing organization. Its functions would be to *coordinate* (research projects, partners, or clients), to serve as a *clearinghouse* linking expertise both on and off campus, to assist in identifying and *developing* research opportunities (perhaps enabled with seed funding), to *market* the University's capabilities in energy research (to government, industry, and the public), to stimulate the development of *educational* programs, and to manage those *facilities* designed to support University-wide, multidisciplinary research activities.

Organizational Character

The MERC envisions the Phoenix Institute with a very lean administrative structure, consisting of a director and a small administrative staff. Since many of the activities of the Institute would be administrative rather than research in nature (e.g., coordination, government and industrial relations, fund raising, facilities management), a possible approach might be to select as director a full-time administrator, partnered with a world-renowned energy scientist serving as "Chief Scientist" for the Institute, providing major visibility and access to opportunities in energy research.

The MERC proposes that the Phoenix Institute report to the Vice President for Research with an executive committee comprised of the associate deans for research of the key participating schools and colleges (e.g., LS&A, Eng, Med, Bus, Policy). The Michigan Energy Research Council or a similar body formed for that purpose would play an advisory role with respect to the Phoenix Institute as would an external advisory committee composed of leaders in energy research and policy. These leaders would be drawn from industry, government, and other universities.



Research Organization

The Michigan Energy Research Council suggests that the most effective intellectual taxonomy of the Phoenix Institute–and Michigan's broader energy research activities–would be a matrix structure characterized by three axes: character of research activities (e.g., basic energy sciences, energy systems, and energy applications), major research themes (e.g., advanced transportation fuels such as hydrogen, storage technologies such as batteries, energy efficient technologies such as solid-state luminescence and solar collectors, and primary energy systems such as nuclear fission and fusion), and research clients (e.g., federal agencies such as DOD and DOE, industry, state agencies, and national laboratories). To illustrate, it is useful to discuss each in turn:

Research Character: While the University of Michigan has a research base characterized by unusual breadth across the physical, biomedical, social, and engineering sciences, its visibility in energy is more limited. To be sure, in some areas closely related to energy research such as nuclear engineering, automotive engineering, manufacturing sciences, and nanosciences, Michigan is clearly recognized as world-class and ranked among world leaders. Complementing its basic research on energy technology, the University has significant expertise and research strength in areas of life cycle energy modeling, energy and climate policy, behavioral sciences, business strategy and economic analysis of energy systems. But the University's visibility is more limited in many energy-specific areas such as fuel cells and energy storage technologies. Hence, in defining the key research themes and priorities for the Phoenix Institute, it will be necessary to both build on existing strengths and develop new capabilities. While building and sustaining basic research capabilities in key supporting scientific areas

such as materials science, nanotechnology, and supercomputer simulation will be important, the Phoenix Memorial Energy Institute must also stimulate research in high-risk/high-payoff areas such as photo and/or nuclear production of hydrogen, ultra-high energy density batteries, thermonuclear fusion, and global energy system analysis.

Research Themes: Michigan's proximity to the nucleus of the American automobile industry provides both an important rationale and opportunity for selecting transportation fuels and alternative mobile energy sources as a major theme for the institute. Furthermore, since the Great Lakes states (and Ontario) produce over 40% of the electricity for North America, with the greatest concentration of nuclear plants in the nation, both central station electricity generation and distribution in general, and nuclear power in particular, must also be a major theme. (This aligns well with not only the original intent of the Michigan Memorial Phoenix Project but also with the presence of the nation's leading nuclear engineering program.) Other energy-intensive industrial activity in the Great Lakes region includes heavy manufacturing and chemical processing as important areas for applied energy research. In additional to its focus on alternative energy sources, the University will continue its leadership role in the development of more sustainable end-use technologies for transportation, industrial, and building sectors. The challenge will be to find the key themes that link both the established and proposed research programs into a coherent whole for the University.

Clients: Clearly Michigan industry would be a key client. While the automobile industry and electrical utilities are obvious clients, manufacturing and chemical processing are also key areas of energy utilization. On the broader regional level, other energy-intensive industries such as gas and oil and nuclear power are important. Looking into the future, the creation of new energy industries through technology transfer, particularly in the knowledge services area is an important priority of the Phoenix Institute. Michigan state government is also an important client because of their responsibility to develop policies and programs aimed at securing the state's economic prosperity and social well-being. At the federal level, the key clients would be key agencies such as DOE, DOD, NSF, NIST, NASA, DOT, and EPA. Clearly the venture capital community is also an important client. There are a number of other organizations that will play the role both of clients and collaborators such as other Michigan research universities (MSU, WSU, MTU), state technology organizations (NextEnergy and Michigan Economic Development Corporation), national laboratories (e.g., Oak Ridge, Argonne, Los Alamos, NREL, and Idaho), and other major research universities with strong energy programs (e.g., Stanford, Purdue, MIT, Texas).

Educational Mission

The Phoenix Institute would also have a parallel mission to develop, stimulate, and support education programs in energy science, technology, and policy at the undergraduate, graduate, and professional school level. Although such instruction would be provided through existing academic programs, the University-wide character of the Phoenix Institute would allow it to assemble faculty teams drawn from various academic units to develop the multidisciplinary instruction required in this area. Here it should be noted that existing courses in the energy area have experienced a very high student interest at both the undergraduate and graduate level.

Necessary Resources

While building upon established strengths in areas such as automotive engineering, nuclear engineering, and nanosciences will jump-start Michigan's visibility in energy research, it must also be realized that its recognition as a comprehensive energy research center will take both time and investment. For example, it took over a decade to establish the University as an international leader in areas such as automotive engineering and manufacturing sciences.

An important precursor to launching the Phoenix Institute would be the initiative proposed by the Vice President for Research to recruit world-class faculty in key technical energy areas. Such appointments would be targeted to fill important gaps in our current portfolio of energy research activities. Similarly, the commitment of the University to renovate the Phoenix Memorial Laboratory to create a multidisciplinary energy research environment, with the third floor of the facility housing a new Hydrogen Energy Technology Laboratory, represents an important early step.

As additional steps, the MERC would strongly recommend that private gifts be sought to recapitalize the endowment of the Phoenix Memorial Energy Institute (a.k.a., the Michigan Memorial Phoenix Project). Although the original endowment of the Phoenix Project in the 1950s was roughly $70 million (in 2006 dollars), today it has eroded to less than $1.5 million. We believe that, both because of the critical importance of energy research and the status of the Phoenix Institute as the University's World War II Memorial, this should be an attractive opportunity for many donors. We recommend that it be included as an element of the Michigan Difference campaign, and that over the next decade an effort be made to raise $100 million in endowment for this important activity. A near-term goal for this fund-raising effort would be to generate sufficient endowment ($10 million) to support the core administrative operations of the Phoenix Institute (i.e., director, staff, and operations).

Furthermore, although the renovation of the Phoenix Memorial Laboratory is a helpful first step, it falls far short of the facilities needs to build major research programs in a laboratory-intensive field such as energy research. Just as the Michigan Memorial Phoenix Project was created after the Second World War, the University of Michigan embarked on a series of projects to expand its science and engineering infrastructure across the campus. These investments have been repaid many times over as Michigan took its place as a leader in basic and applied research. In the last few years, Michigan has invested heavily in new infrastructure devoted to the important areas of medicine, biology, and information technology. However, the classroom and laboratory space devoted to the study of energy and environmental systems have remained largely unchanged, and some of it is outdated and woefully inadequate. Much of the energy research activity takes place in four of the oldest buildings on North Campus, the Phoenix Memorial Laboratory/Ford Nuclear Reactor, the G. G. Brown Laboratory, the Lay Automotive Laboratory, and the Herbert H. Dow Building. Three of these buildings are over 40 years old, and the Dow building is over twenty years old. It would be prohibitively expensive to upgrade these buildings to adequately serve the need of advanced energy research. For example, research into hydrogen generation, storage, and use requires specialized facilities that are designed to cope with the particular safety issues associated with the handling of hydrogen gas. Similar issues arise with the design and testing of novel distributed energy production systems. Facilities are needed to test fuel cells, batteries, and other complex electro-chemical systems.

As the energy research activity at the University builds rapidly over the next several years, there will likely be a need to repurpose or renovate other laboratory space in existing facilities, likely on the North Campus. Eventually, on the time scale of several years, we believe it will be necessary to acquire additional heavy-duty laboratory space amounting to 200,000 nsf or more. Here we suggest that the University look to state capital outlay for the support of a major research and instructional facility in energy research. The decade-long bottleneck in major state capital outlay for higher education has created a log-jam that is likely to be broken when (and if) the Michigan economy turns around. The University should be positioned to take advantage of this with a very compelling project, and we believe importance of the Phoenix Institute to the future of Michigan (and the nation) would make a particularly strong priority for state funding.

We also recommend that steps be taken to explore the possibility of state support for this new enterprise, perhaps analogous to the Research Excellence Fund of the 1980s, in which the state provide a base appropriation to the University of Michigan of $11 million annually for launching research initiatives of major importance to the state.

During the 1980s the administration of Governor James Blanchard supported a highly successful effort to invest in the research capacity of its universities similar through the Research Excellence Fund. Approximately $9 – $10 million a year for a seven year period was focused on three major research centers at the University of Michigan College of Engineering: the Center for Research on Integrated Manufacturing, the Center for Advanced Electronics and Optics Technology, and the Center for Machine Intelligence. The impact of this investment was quite extraordinary: the production of cutting edge research, products, and methodologies in manufacturing, information technology, microelectronics, optics, MEMS, and biotechnology; the spinoff of sixteen successful companies; numerous technologies that were adopted by Michigan industry; the involvement in research of hundreds of Michigan companies that became partners in the centers; and a ramping up of federal research funding attracted by the UM College of Engineering by a factor of seven-fold, from $18 million a year to over $140 million a year, leveraging the state investment by over a factor of 10.

We have laid the foundation for such a request in the Michigan Roadmap document, presented to the Governor and the Legislature last fall with the recommendation:

> *The quality and capacity of Michigan's learning and knowledge infrastructure will be determined by the leadership of its public research universities in discovering new knowledge, developing innovative applications of those discoveries that can be transferred to society, and educating those capable of working at the frontiers of knowledge and the professions. State government should strongly support the role of these institutions as sources of advanced studies and research by dramatically increasing public support of research infrastructure, analogous to the highly successful Research Excellence Fund of the 1980s.*

NEXT STEPS

The Michigan Energy Research Council suggests the following timetable for University actions to establish and build the Phoenix Memorial Energy Institute:

Spring, 2006: Commit to VP-Research Initiative to build world-class faculty capacity in key areas of energy research.

Spring, 2006: Executive Officers approve in principle the formation of the Phoenix Memorial Energy Institute.

Spring, 2006: Include Phoenix Institute as priority of Michigan Difference Campaign with near-term goal of $10 million to fund the core administrative operations and a longer term goal of $100 million to recapitalize the Michigan Memorial Phoenix Project endowment.

September, 2006: The Regents formally approve and announce the creation of the Phoenix Memorial Energy Institute.

Fall, 2006: Michigan Energy Conference, Public Announcement of Phoenix Institute; Dedication of Renovation Phoenix Memorial Laboratory (President Coleman, Governor Granholm, Secretary Bodman, NSF Director Arden Bement, Ford CEO William Ford, DTE CEO Anthony Early, and CMS CEO David Joos).

Winter, 2007: Search and selection of Director and Chief Scientist of Phoenix Institute.

Fall, 2007: Completion of renovation of Phoenix Memorial Laboratory; Assignment of research space to energy projects in ITI Building.

Fall, 2007: Petition State of Michigan for capital outlay funds for new multidisciplinary energy research laboratory; work with MSU, WSU, MTU to achieve commitment to new Research Excellence Fund ($100 million in base support; $35 million to University of Michigan.)

CONCLUSION

The state of Michigan and the nation are beginning to awaken to the challenge of sustainable energy production and use, especially with regard to our use of fossil fuels for transportation and energy generation. In earlier times Michigan benefited immensely from the growth of manufacturing and automotive technology, but today we find ourselves in changing times, where the automotive industry is struggling to survive in a global economy. As the state's leading institution for creating the future, the University of Michigan faces the challenge of assisting in the transformation of the Michigan economy.

A commitment and investment by the University of Michigan in advanced energy research will be seen by our local industry, by state government, and by the citizens of Michigan as a vital contribution to the economic well-being of our state. By making significant investments now, we will be positioned to contribute as well to the national interests and to global sustainability.

Today the development and implementation of sustainable energy technology and policy presents perhaps the greatest challenge to our state and nation. Now is the time for the University of Michigan to seize the opportunity to contribute solutions to this challenge.

Furthermore, the re-dedication of the Michigan Memorial Phoenix Project to this imperative by reconfiguring it as the Phoenix Memorial Energy Institute would be a timely reminder of the sacrifices of previous generations of the University of Michigan community. It would demonstrate that the University of Michigan is once again prepared to provide leadership and commitment to the future of our state, the nation, and the world.

APPENDIX A

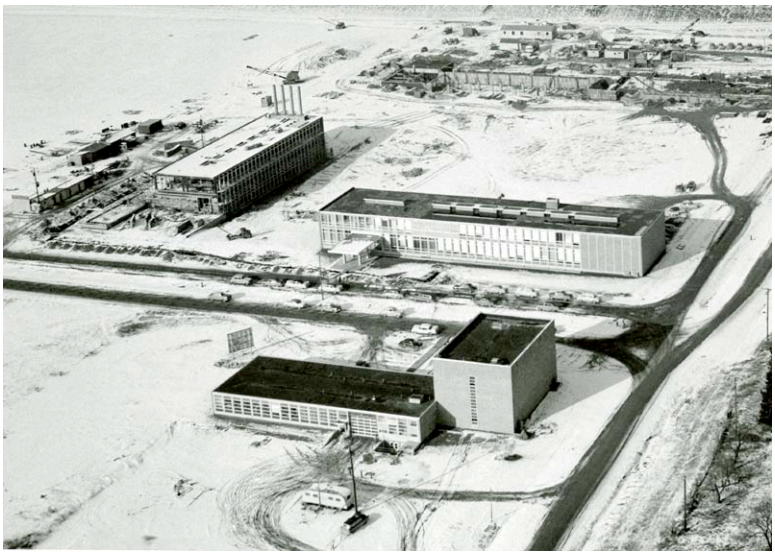
THE MICHIGAN MEMORIAL PHOENIX PROJECT: A BRIEF HISTORY

One of the most significant initiatives of the University following WWII was the Michigan Memorial Phoenix Project, a major nuclear research laboratory established by the University and funded by private gifts as a memorial to the 579 members of the Michigan family who had lost their lives in the war. Interestingly enough, it was a student committee that pressed the University to action on the matter and urged the Regents to accept the idea of the Phoenix Project after it was first developed and approved by student government. The students sought to commemorate the memory of those who made the supreme sacrifice by attempting to develop a project that would aid all mankind in living in a war-free world rather than to attempt to build "a mound of stone the purpose of which might soon be forgotten."

In May, 1948, the Regents adopted a resolution that "the University of Michigan create a War Memorial Center to explore the ways and means by which the potentialities of atomic energy may become a beneficent influence in the life of man, to be known as the Phoenix Project of the University of Michigan." Under the leadership of University President Alexander Ruthven and Albert Lang, president of the General Electric Company, the Phoenix Campaign quickly grew into a well-organized national effort that raised $6.5 million for a research building, a research endowment, and thanks to a one-million-dollar gift from the Ford Motor Company, a nuclear reactor (called the Ford Nuclear Reactor). It is noteworthy that the membership of the fund-raising committee included three students who were all veterans of World War II.

Ruthven called the Phoenix project "the most important undertaking in the University's history." The University was paying tribute to the sacrifices of its men and women during the war by accepting the momentous responsibility of studying the peaceful applications of atomic energy. Even President Eisenhower highlighted the importance of the Phoenix Project: "Few causes are more urgent today and more noteworthy of your support. In war or in peace, the atomic research being done at the University of Michigan will strengthen America."

The Phoenix Project Laboratory was constructed as one of the first buildings on the North Campus of the University.



The construction of the Phoenix Laboratory (upper left)

Although all programs in the University were involved in the Michigan Memorial Phoenix Project, the College of Engineering had a particular responsibility to develop both instructional and research programs in nuclear energy. A professor of electrical engineering, Henry Gomberg, was named as the first director of the Phoenix Project. It is interesting that the actual plans for the nuclear reactor in the Phoenix Laboratory were classified during the early phases of its construction, and the associated Department of Nuclear Engineering that would utilize the facility was the first such program in the United States. It is also important to note that some 50 years later, the Phoenix Laboratory, the Ford Nuclear Reactor, and the Department of Nuclear Engineering all continue to make significant contributions to nuclear energy research and application, including the first observation of gravitationally induced quantum interference, seminal experiments involving neutron scattering, and the first demonstration of low-enrichment (non-weapons-grade) uranium fuel for research reactors, a major contribution to anti-proliferation efforts. The Phoenix Project enriched University life through the visits of distinguished scientists such as Robert Oppenheimer and Hans Bethe. It also provided support and facilities for the hundreds of nuclear engineers and scientists who have studied and trained in the Phoenix Laboratory. The Michigan Memorial Phoenix Project was recognized in 2001 by the American Nuclear Society as "a unique and pioneering atomic research program, as a permanent memorial to the University's soldiers who fought and died in World War II, and as a symbol of the University of Michigan's commitment to the peaceful and socially responsible use of science and technology.

APPENDIX B

REGENTS COMMUNICATION (JULY, 2004)

Regents Information Item: In May, 1948, the Regents of the University of Michigan resolved that "*the University of Michigan create a War Memorial Center to explore the ways and means by which the potentialities of atomic energy may become a beneficent influence in the life of man, to be known as the Phoenix Project of the University of Michigan.*" Construction of the Michigan Memorial Phoenix Project (MMPP) laboratory was completed in 1951. The Ford Nuclear Reactor became part of the project when it went critical in 1957 and served researchers until it was deactivated in July of 2003.

Since the establishment of MMPP, significant progress has been made in putting atomic/nuclear energy to use for peaceful purposes. Today nuclear science is used routinely in medicine, engineering, geology, anthropology, and a host of other fields, to advance knowledge and improve the human condition. Such progress not withstanding, two major challenges embodied in MMPP remain as relevant and intractable today as they were in the late 1940s: the need for a viable, long-term energy policy and the continued need to find ways for people and nations to live together peacefully.

To assure that its WW II memorial remain a relevant and lasting tribute to those who fought and gave their lives during the War, the University will refocus the mission of MMPP to include research on the development of energy sources and energy policies that will promote world peace, the responsible use of the environment, and economic prosperity. In doing so, it is envisioned that MMPP will become the coordinating center for research activities from a variety of disciplines that are presently dispersed across multiple schools and colleges. Research areas will include energy generation from sources such as nuclear, hydrogen, solar, wind, and geothermal, as well as energy storage, energy management, and energy policy. Research perspectives will continue to encompass the natural and social sciences, engineering, medicine, and the arts and humanities.

APPENDIX C

MICHIGAN ENERGY RESEARCH COUNCIL 2005-2006

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